Physics 101	Hour Exam 2	April 7, 2014

Last Name: ______________ **First Name** ______________ **ID** ______________

Discussion Section: ________________ **Discussion TA Name:** ________________

Instructions—Turn off your cell phone and put it away.
Calculators cannot be shared. Please keep yours on your own desk.

This is a closed book exam. You have 90 minutes to complete it.
This is a multiple choice exam. Use the bubble sheet to record your answers.

1. Use a #2 pencil; do **not** use a mechanical pencil or a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the version circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

5. Stop **now** and double-check that you have bubbled-in all the information requested in 2 through 4 above and that your marks meet the criteria in 1 above. Check that you do not have more than one circle marked in any of the columns.

6. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

7. Write in your course on the **COURSE LINE** and on the **SECTION** *line*, print your **DISCUSSION SECTION**. (You need not fill in the INSTRUCTOR line.)

8. Sign **(DO NOT PRINT)** your name on the **STUDENT SIGNATURE** *line*.

*Before starting work, check to make sure that your test booklet is complete. After these instructions, you should have **8*** ***numbered pages*** *plus 2 Formula Sheets.*

On the test booklet:
Write your **NAME**, your **Discussion TA's NAME**, your **DISCUSSION SECTION** and your **NETWORK-ID**. Also, write your **EXAM ROOM** and **SEAT NUMBER**.

When you are finished, you must <u>hand in BOTH the exam booklet AND the answer sheet</u>. Your exam will not be graded unless both are present.

***<u>Academic Integrity</u>*—Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

Exam Format & Instructions:

This exam is a mixture of

* Two-Answer Multiple Choice	(2 points each)
* Three-Answer Multiple Choice	(3 points each)
* Five-Answer Multiple Choice	(6 points each)

There are 24 problems for a maximum possible raw score of 105 points.

Instructions for Two-Answer Multiple Choice Problems:
Indicate on the answer sheet the correct answer to the question (*a* or *b*).
Each question is worth 2 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

Instructions for Three-Answer Multiple Choice Problems:
Indicate on the answer sheet the correct answer to the question (*a, b* or *c*).
Each question is worth 3 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

Instructions for Five-Answer Multiple Choice Problems:
Indicate on the answer sheet the correct answer to each question (*a, b, c, d* or *e*).
Credit is awarded in the following way:
- If you mark one answer and it is correct, you will receive 6 points;
- If you mark two answers, and one of them is correct, you will receive 3 points;
- If you mark three answers and one of them is correct, you will receive 2 points.
- If you mark no answer or more than three answers, you will receive 0 points.

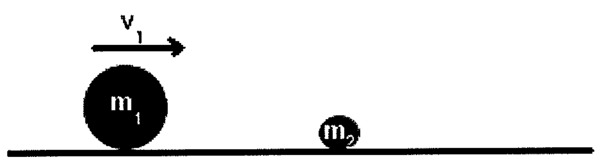
Check to make sure that you bubble in ALL of your answers on the scantron (answer sheet).
Only what is marked on your scantron/answer sheet will count!

1) The Work-Kinetic Energy Theorem is

a. only true for conservative forces.
b. always true.
c. not true if friction is present.

The next two questions pertain to the situation described below.

A mass $m_1 = 0.17\ kg$ is moving at a velocity $0.26\ m/s$ towards a smaller stationary mass $m_2 = 0.02\ kg$. In the collision, it sticks to it and continues to move in the same direction.



2) The linear momentum of the system after the collision is:

a. *The same as before the collision.*
b. *Larger than before the collision.*
c. *Smaller than before the collision.*

3) Determine the velocity v_2 of m_2 after the collision

a. $v_2 = 0.92\ m/s$
b. $v_2 = 0.12\ m/s$
c. $v_2 = 0.46\ m/s$
d. $v_2 = 0.058\ m/s$
e. $v_2 = 0.23\ m/s$

$$m_1 v_1 = (m_1 + m_2) V$$

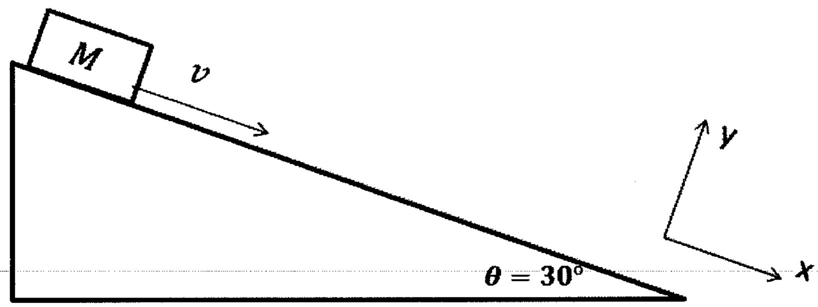
$$V = \frac{m_1}{m_1 + m_2} v_1$$

$$= \frac{0.17}{0.17 + 0.02} 0.26\ m/s$$

$$= 0.23\ m/s$$

The next three questions pertain to the situation described below.

Consider a box of mass $M = 8\ kg$ on an incline plane which make an angle $\theta = 30^o$ to the horizontal. The box slides with constant speed.



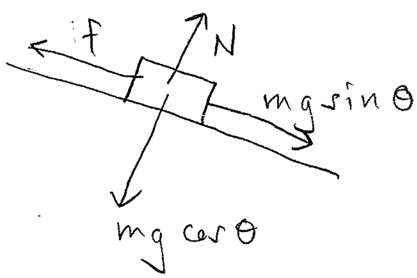
4) If the box slides *19.8 meters*, what is the magnitude of the work done by friction?

a. *777 J*
b. *3880 J*
c. *155 J*
d. *2330 J*
e. *1350 J*

$$|W_f| = |W_{gravity}|$$
$$= mgh$$
$$= mgd\sin\theta$$
$$= 8\ kg \times 9.8\ m/s^2 \times 19.8\ m \times \sin 30^\circ = 777\ J$$

5) Determine the coefficient of friction.

a. *1.7*
b. *0.87*
c. *0.12*
d. *0.58*
e. *0.19*



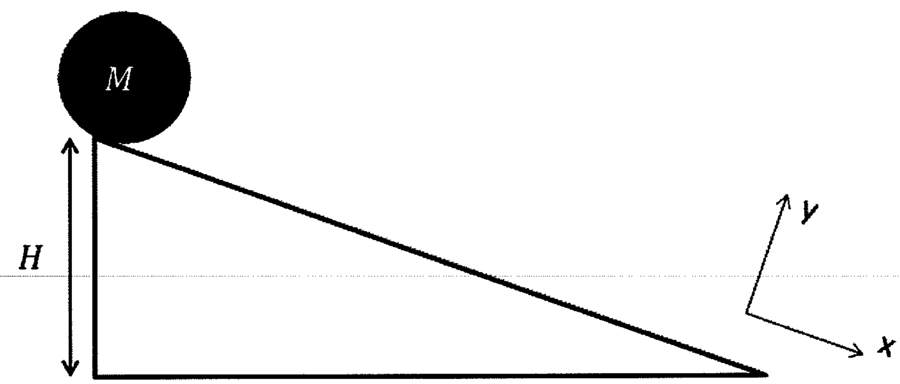
$$f = \mu_K N = mg\sin\theta$$
$$\mu_K mg\cos\theta = mg\sin\theta$$
$$\mu_K = \tan\theta = \tan 30^\circ = 0.58$$

6) The angle of the incline is now increased by 10° to 40°. The box will slide with a

a. larger constant speed
b. smaller constant speed
c. non-constant speed

The next three questions pertain to the situation described below.

A solid sphere of mass $M = 8\ kg$ and radius $R = 0.26\ m$ rolls from rest down a ramp without slipping. The initial height of the sphere is $H = 2.9\ m$ as shown. The moment of inertia of the sphere is $I = 2/5\ MR^2$.



7) What is the total kinetic energy of the sphere KE_{TOT} at the bottom of the ramp?

a. $28.5\ J$
b. $228\ J$
c. $20.4\ J$
d. $342\ J$
e. $684\ J$

$$KE = mgH$$
$$= 8\ kg \times 9.8\ m/s^2 \times 2.9\ m$$
$$= 227.4\ J$$

8) What is the rotational kinetic energy of the sphere KE_{ROT} at the bottom of the ramp?

a. $97.5\ J$
b. $45.6\ J$
c. $114\ J$
d. $342\ J$
e. $65\ J$

$$\frac{KE_{ROT}}{KE_{TRANS}} = \frac{\frac{1}{2} I \omega^2}{\frac{1}{2} M v^2} = \frac{\frac{2}{5} MR^2 \omega^2}{M(\omega R)^2} = \frac{2}{5}$$

$$v = \omega R$$

$$\Rightarrow \frac{KE}{KE_{ROT}} = \frac{KE_{TRANS}}{KE_{ROT}} + \frac{KE_{ROT}}{KE_{ROT}} = \frac{5}{2} + 1 = \frac{7}{2}$$

9) If the speed of the sphere at the bottom of the ramp $v = 6\ m/s$ what is the rotational speed ω at the same point?

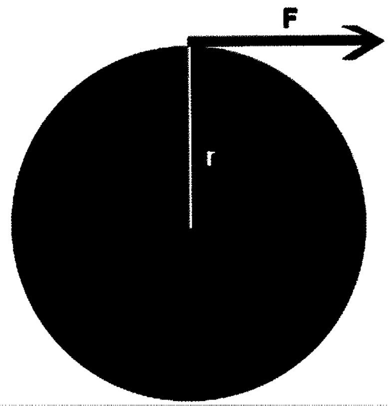
$$\Rightarrow KE_{ROT} = \frac{2}{7} KE = \frac{2}{7} 227.4\ J$$
$$= 65\ J$$

a. $\omega = 1.6\ rad/s$
b. $\omega = 23\ rad/s$
c. $\omega = 46\ rad/s$

$$v = \omega R \Rightarrow \omega = \frac{v}{R}$$
$$= \frac{6\ m/s}{0.26\ m} = 23.1\ \frac{rad}{sec}$$

The next three questions pertain to the situation described below.

A force of $F = 8\ N$ acts tangentially on a rotating disk of mass $M = 4.8\ kg$ and radius $r = 1\ m$, as shown ($I_{disk} = Mr^2/2$). As a result, the disk's rotation accelerates from a rotational angular velocity of $\omega_0 = \pi\ rad/s$ to $\omega_f = 4\ \pi\ rad/s$.



10) What is the magnitude of the torque acting on the disk?

$\tau = Fr = 8\ N \times 1 m = 8\ Nm$

a. $\tau = 11\ N\,m$
b. $\tau = 5\ N\,m$
c. $\tau = 8\ N\,m$

11) What is the magnitude of the initial angular momentum of the disk?

a. $L = 1.2\ \pi\ kg\ m^2/s$
b. $L = 2.4\ \pi\ kg\ m^2/s$
c. $L = 4.8\ \pi\ kg\ m^2/s$
d. $L = 19.2\ \pi\ kg\ m^2/s$
e. $L = 9.6\ \pi\ kg\ m^2/s$

$L = I\omega = \frac{1}{2} M r^2 \omega$

$= \frac{1}{2}\ 4.8\ kg \times (1\ m)^2 \times \pi\ rad/s$

$= 2.4\pi\ kg\ m^2/s$

12) What is the magnitude of the final angular momentum of the disk?

a. $L = 19.2\ \pi\ kg\ m^2/s$
b. $L = 2.4\ \pi\ kg\ m^2/s$
c. $L = 9.6\ \pi\ kg\ m^2/s$
d. $L = 1.2\ \pi\ kg\ m^2/s$
e. $L = 4.8\ \pi\ kg\ m^2/s$

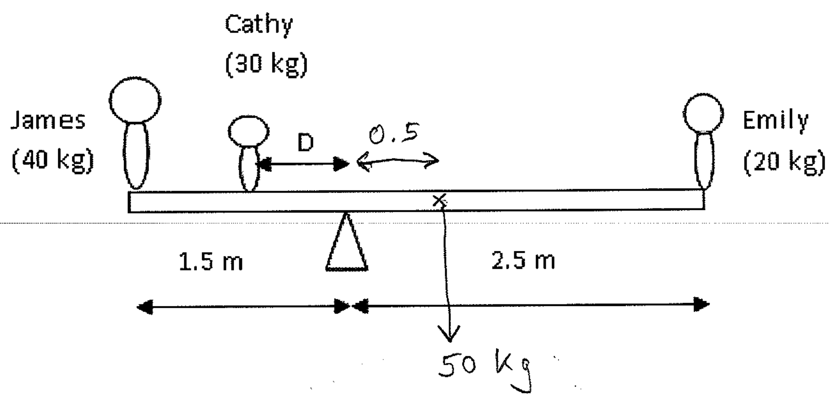
$L = I\omega = \frac{1}{2} M r^2 \omega$

$= \frac{1}{2}\ 4.8\ kg \times (1\ m)^2 \times 4\pi\ rad/s$

$= 9.6\pi\ kg\ m^2/s$

The next two questions pertain to the situation described below.

A see-saw is made by pivoting a uniform *4 m*-long board at a pivot point *1.5 m* from one of its ends, as shown in the figure. The board has a mass of *50 kg*, James has a mass of *40 kg* and sits at the left end, and Emily has a mass of *20 kg* and sits at the right end.



13) What distance *D* to the left of the pivot should Cathy, whose mass is *30 kg*, sit in order for the see-saw to be balanced (i.e. in static equilibrium)?

$40 \times 1.5 + 30 \times D = 20 \times 2.5 + 50 \times 0.5$

$30 \times D = 15$

$D = 0.5\ m$

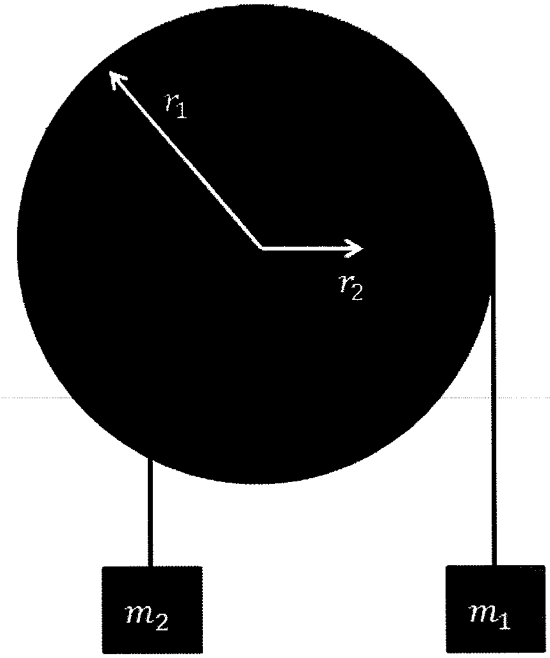
a. $D = 0.75\ m$
b. $D = 1\ m$
c. $D = 0.25\ m$
d. $D = 0.5\ m$
e. $D = 0.333\ m$

14) If Cathy gains some weight, but the other kids do not, how would her position have to change to keep the see-saw balanced?

a. *She would have to sit closer to James (i.e. D would get larger).*
b. *Her position would be the same*
c. *She would have to sit closer to the pivot (i.e. D would get smaller).*

The next three questions pertain to the situation described below.

A wheel of radius $r_1 = 0.8\ m$ and hub of radius $r_2 = 0.4\ m$ is shown in the diagram. Two masses are hung from the wheel-hub system. The mass m_2, on the left, is hung from the hub. The mass m_1 is hung from the wheel. The system is in equilibrium. The moment of inertia for the disk-hub system is $I = 1.34\ kg\ m^2$.



15) Which of the following statements are true:

a. $m_1 = m_2$
b. $m_1 < m_2$
c. $m_1 > m_2$

$$m_1 g r_1 = m_2 g r_2$$
$$\Rightarrow m_1 = \frac{r_2}{r_1} m_2 < m_2$$

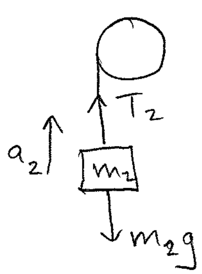
16) The mass $m_2 = 1.6\ kg$. What is the mass of m_1?

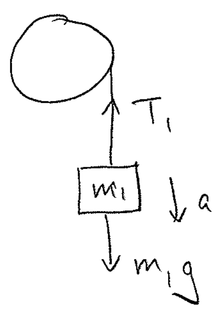
a. $m_1 = 0.8\ kg$
b. $m_1 = 0.27\ kg$
c. $m_1 = 3.2\ kg$

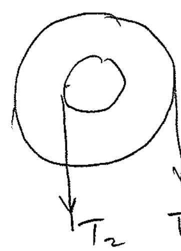
$$m_1 = \frac{r_2}{r_1} m_2 = \frac{0.4}{0.8} 1.6\ kg = 0.8\ kg$$

17) If $m_1 = 0.88\ kg$ is large enough for the system to rotate, when $m_2 = 1.6\ kg$, what is the magnitude of the acceleration of the mass m_2?

a. $a = 3.9\ m/s^2$
?) b. $a = 0.37\ m/s^2$
c. $a = 0.19\ m/s^2$







$$\alpha = \frac{a_1}{r_1} = \frac{a_2}{r_2}$$
$$\Rightarrow a_1 = \frac{r_1}{r_2} a_2$$

$$T_2 - m_2 g = m_2 a_2$$
$$T_2 = m_2 (a_2 + g)$$

$$T_1 - m_1 g = -m_1 a_1$$
$$T_1 = m_1 (g - a_1) = m_1 \left(g - \frac{r_1}{r_2} a_2\right)$$

$$T_1 r_1 - T_2 r_2 = I \alpha = I \frac{a_2}{r_2}$$

$$m_1 \left(g - \frac{r_1}{r_2} a_2\right) r_1 - m_2 (a_2 + g) r_2 = I \frac{a_2}{r_2}$$
$$a_2 = g (m_1 r_1 - m_2 r_2) \Big/ \left(\frac{I}{r_2} + m_1 \frac{r_1^2}{r_2} + m_2 r_2\right) = 0.116\ m/s^2$$

The next four questions pertain to the situation described below.

A puck of mass $m = 1.6\ kg$ is attached to a massless string threaded through a frictionless hole in a sheet of ice. The puck slides on the ice sheet, kept in a circular path of constant radius by the string.

18) If the puck initially rotates with an angular speed $\omega = 4\ rad/s$ at a radius $R = 0.8\ m$, what is the angular momentum of the puck?

a. $L = 5.1\ kg\ m^2/s$
b. $L = 0.26\ kg\ m^2/s$
c. $L = 4.1\ kg\ m^2/s$

$$L = I\omega = mR^2\omega$$
$$= 1.6\ kg \times (0.8\ m)^2 \times 4\ rad/s$$
$$= 4.1\ kg\ m^2/s$$

19) The string is pulled such that the radius of the motion is decreased by a factor of 2. Which of the following statements is true:

a. $\omega_{new} = \omega/4$
b. $\omega_{new} = 4\ \omega$
c. $\omega_{new} = 2\ \omega$
d. $\omega_{new} = \omega$
e. $\omega_{new} = \omega/2$

$$I_1 \underbrace{\omega_1}_{\omega} = I_2 \underbrace{\omega_2}_{\omega_{new}} \qquad \frac{I_2}{I_1} = \frac{\cancel{m} R_2^2}{\cancel{m} R_1^2} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

$$\omega_{new} = \frac{I_1}{I_2}\omega = 4\omega$$

20) The string is pulled such that the radius of the motion is decreased by a factor of 2. Which of the following statements is true:

a. *Kinetic energy of the puck stays the same.*
b. *Kinetic energy of the puck decreases.*
c. *Kinetic energy of the puck increases.*

$$\frac{K_2}{K_1} = \frac{\cancel{\frac{1}{2}} I_2 \omega_2^2}{\cancel{\frac{1}{2}} I_1 \omega_1^2} = \frac{1}{4} \times (4)^2 = 4$$

21) Which of the following is a conserved quantity in this system:

a. *potential energy* ← also conserved since it's zero throughout
b. *angular momentum*
c. *kinetic energy*

22) We toss an egg onto the floor, and it breaks. We toss an egg onto a pillow on the floor, and it does not break. The egg that does not break experiences a smaller

a. *impulse.*
b. *change in momentum.*
c. *maximum force.*

23) Two identical blocks ($m = 16\ kg$) travel along the x-axis. One has $v = 6.9\ m/s$, the other $v = -4.4\ m/s$. They collide. One block breaks into two identical pieces with $m_{half} = 8\ kg$. The pieces travel at equal speeds, but in opposite directions, along the y-axis. After the collision the *unbroken* block is travelling along the x-axis at

two pieces have zero total momentum

$$m v_1 + m v_2 = 0 + mV$$

$$m(v_1 + v_2) = mV$$

$$V = v_1 + v_2 = 6.9\ m/s - 4.4\ m/s = 2.5\ m/s$$

a. $v = 1.2\ m/s$
b. $v = 0\ m/s$
c. $v = 2.5\ m/s$
d. $v = 3.8\ m/s$
e. $v = 5\ m/s$

24) A car of mass $M = 1825\ kg$ is travelling horizontally at $13\ m/s$ when it goes off a cliff and crashes into a valley $100\ m$ below. How fast is the car going just before it crashes?

a. $v = 138\ m/s$
b. $v = 32.6\ m/s$
c. $v = 69.2\ m/s$
d. $v = 31.4\ m/s$
e. $v = 46.1\ m/s$

$$KE_1 + mgh = KE_2$$

$$\frac{1}{2}\cancel{m}v_1^2 + \cancel{m}gh = \frac{1}{2}\cancel{m}v_2^2$$

$$v_2 = \sqrt{v_1^2 + 2gh}$$

$$= \sqrt{(13\ m/s)^2 + 2 \times 9.8\ m/s^2 \times 100\ m}$$

$$= 46.1\ m/s$$